§8. Performance Test of Personal RF Electromagnetic Fields Monitor for Area Monitoring at Magnetic Confinement Fusion Facility

Uda, T., Tanaka, M.,
Wang, J., Fujiwara, O. (Nagoya Institute of Technology),
Kamimura, Y. (Utsunomiya Univ.)

Environmental electric and magnetic field strength around a large magnetic plasma experimental facility like LHD and the auxiliary heating devices had been measured. The international guidelines for various electromagnetic fields have been proposed with the World Health Organization (WHO) and the International Commission on Non-ionizing Radiation Protection (ICNIRP). Also the Association of Radio Industries and Business proposed guidelines for radiofrequency-exposure protection named RCR STD-38 2.0 in Japan. The property of environmental electromagnetic fields around the magnetic fusion experimental facility is to be generated statistically, that is including various frequencies of radio wave. The leakage of static magnetic field strength had been measured since the first plasma experiment of the LHD in 1998. The frequencies of electromagnetic sources are from extremely low frequency (ELF) to extremely high frequency (EHF). There are three plasma heating devices of Neutral Beam Injector (NBI: ELF), Ion Cyclotron Ranges of Frequency (ICRF: 25-100 MHz), and Electron Cyclotron Heating (ECH:84-168 GHz).

To continuously measure the leakage of high frequency electric and magnetic fields from ICRF, three axes electric and magnetic probes named EM-300EP (Narda S.T.S.) and data logging system had been developed. Also to detect the low level magnetic field we applied by using more sensitive SRM-3000 detector. Then it could be successfully detected. However such probe system is not suitable for continuous monitoring because of high load to the data processing system. Also it is difficult to measure multiple points. From occupational safety point of view, we made feasibility study if the personal monitors are applicable as convenient monitoring system.

Two models of “Radman” RF monitors (Narda S.T.S.), namely fast and slow types were applied. Each Radman is equipped with two diode-based detectors: one for electric field measurement and one for magnetic field measurement. The sensors are designed for detection in three dimensions. The range of magnetic field frequency is between 3 MHz and 1 GHz and range of electric field frequency is from 3 MHz to 7 GHz (slow type) or 40 GHz (fast type). The relative value of field strength is from 0% to 160%, in accordance with the Japan RCR-STD38 standard. These detectors have two averaging periods. Model ESM-20 (fast type) has an averaging period of 30 ms, and Model ESM-30 (slow type) has an averaging period of 1 s. According to RCR-STD38, the relative value of field strength is expressed by the following equations:

$$IR_E\,(\%) = 100 \times E^2/E_0^2, \qquad (1)$$
$$IR_H\,(\%) = 100 \times H^2/H_0^2. \qquad (2)$$

Here, E is measured electric field (V/m) and E_0 is the standard regulation level. For magnetic field, IR_H (%) is expressed as H^2/H_0^2. Continual data acquisition with the Radman RF monitors was carried out using a personal computer connected by optical fiber via RS-232C. For data acquisition using several monitors, we have developed original software. The sampling time is 0.2 s.

Figure 1 shows the time course in discrete steps within a specified time interval at 60 MHz. The output of electric field on the fast type Radman monitor changed stepwise. However, the output on the slow-type Radman monitor exhibited a transient phenomenon. Moreover, the output of magnetic field on both fast-type and slow-type monitors exhibited transient phenomena. The time constants of the transient phenomena can be estimated using the following equation:

$$I = I_0[1-\exp(-t/\tau)] \quad \text{: rise phase}, \qquad (3)$$

where I and I_0 are the output intensities from the monitor, τ is a time constant, and t is the elapsed time. The time constant of the electric-field sensor for the slow-type Radman was approximately 1.1 s, corresponding to the averaging period. That for the fast type was below 0.2 s, corresponding to the sampling interval time. The time constant for the fast-type monitor was much faster than the sampling interval time. On the other hand, the time constants for the magnetic-field sensors were approximately 1.1 s, regardless of the type of monitor. From results of the feasibility study, as viewpoint of safety assessment, the fast-type monitor would be more suitable for an area monitor at a magnetic confinement fusion test facility.

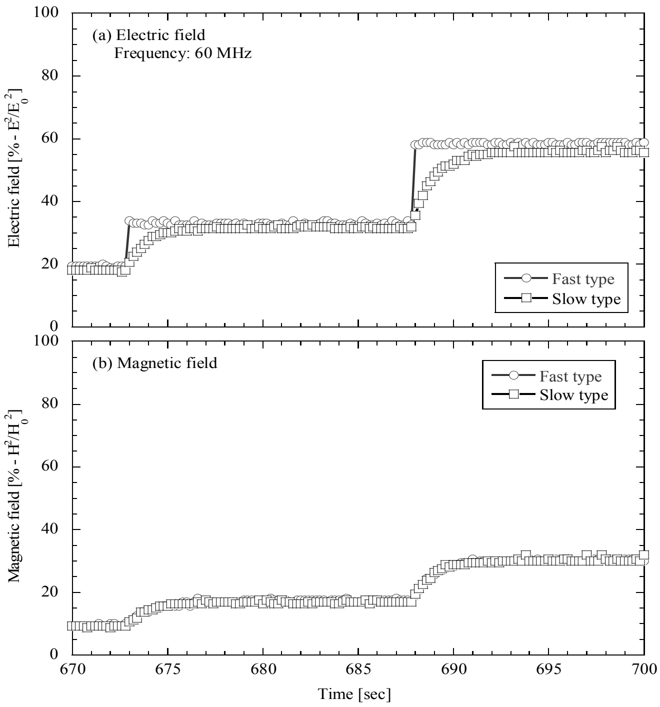

Figure 1. Time course in discrete steps within specified time interval at 60 MHz: (a) electric field, (b) magnetic field